

A 27- And A 20- Resistors Are Connected In Parallel, And The Combination Is Connected Across A 240-v

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Understanding the behavior of resistors in electrical circuits is fundamental to both theoretical and practical electrical engineering. When resistors are connected in parallel, their combined resistance impacts the current flow and voltage distribution within the circuit. In this article, we will explore the scenario where a 27-ohm resistor and a 20-ohm resistor are connected in parallel, and this combination is then connected across a 240-volt power supply. We will analyze the circuit step-by-step, calculate key parameters such as equivalent resistance, total current, individual currents, and power dissipation, all while emphasizing core principles of parallel resistor circuits.

Understanding Parallel Resistor Circuits

What Is a Parallel Connection?

A parallel connection occurs when two or more components are connected across the same two points, providing multiple paths for current to flow. In such configurations:

- The voltage across all resistors remains the same.
- The total current divides among the resistors inversely proportional to their resistance.

Why Use Parallel Circuits?

Parallel circuits are common in electrical systems due to their advantages:

- If one resistor (or component) fails, the others can continue to operate.
- They enable different resistors to share the same voltage while allowing varying current flows.
- They facilitate easier voltage regulation and distribution.

Analyzing the Circuit: Connecting 27Ω and 20Ω Resistors in Parallel

Given Data:

- Resistor $R_1 = 27 \, \Omega$
- Resistor $R_2 = 20 \, \Omega$
- Supply Voltage $V = 240 \, V$

Objective:

Calculate:

- The equivalent resistance of the parallel combination.
- The total current supplied by the source.
- The individual currents through each resistor.
- The power dissipated in each resistor.

Calculating the Equivalent Resistance

Formula for Parallel Resistance

The equivalent resistance (R_{eq}) of resistors in parallel is given by:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Applying the given values:

$$\frac{1}{R_{eq}} = \frac{1}{27} + \frac{1}{20}$$

Calculating each term:

$$\frac{1}{27} \approx 0.03704$$
$$\frac{1}{20} = 0.05$$

Adding:

$$\frac{1}{R_{eq}} = 0.03704 + 0.05 = 0.08704$$

Therefore:

$$R_{eq} = \frac{1}{0.08704} \approx 11.49 \text{ } \Omega$$

Result: The equivalent resistance of the parallel combination is approximately 11.49 Ω .

Calculating Total Current from the Power Supply

Using Ohm's Law:

$$I_{total} = \frac{V}{R_{eq}}$$

Substituting known values:

$$I_{total} = \frac{240 \text{ V}}{11.49 \text{ } \Omega} \approx 20.88 \text{ A}$$

Result: The total current supplied by the 240 V source is approximately 20.88 amperes.

Determining Individual Currents Through Each Resistor

Since the resistors are in parallel, the voltage across each is 240 V:

- Current through R_1 (27 Ω):

$$I_1 = \frac{V}{R_1} = \frac{240}{27} \approx 8.89 \text{ A}$$

- Current through R_2 (20 Ω):

$$I_2 = \frac{V}{R_2} = \frac{240}{20} = 12 \text{ A}$$

Verify the sum:

$$I_1 + I_2 = 8.89 + 12 = 20.89 \text{ A}$$

This matches the total current calculated earlier, confirming the consistency of the calculations.

Power Dissipation in Each Resistor

Power dissipated by a resistor is given by:

$$P = V \times I = \frac{V^2}{R}$$

- Power in R_1 :

$$P_1 = \frac{V^2}{R_1} = \frac{240^2}{27} = \frac{57600}{27} \approx 2133.33 \text{ W}$$

- Power in R_2 :

$$P_2 = \frac{V^2}{R_2} = \frac{240^2}{20} = \frac{57600}{20} = 2880 \text{ W}$$

Alternatively, using $(P = I^2 R)$:

- Power in R_1 :

$$P_1 = (8.89)^2 \times 27 \approx 79.02 \times 27 \approx 2133.54 \text{ W}$$

- Power in R_2 :

$$P_2 = (12)^2 \times 20 = 144 \times 20 = 2880 \text{ W}$$

Both methods yield consistent results, confirming the power dissipation values.

Implications and Practical Considerations

Voltage and Current Distribution

- Both resistors experience the same voltage of 240 V.
- The current divides inversely proportional to resistance: R_2 conducts more current due to its lower resistance.

Power Ratings and Safety

- The power dissipated in each resistor is significant; ensure resistors are rated for at least these power levels to prevent overheating.
- In real-world applications, resistors often have power ratings (e.g., 5 W, 10 W). The calculated power exceeds typical ratings, indicating that actual resistors should be rated appropriately or that the circuit needs to be designed differently.

Effect of Resistance Values

- Lower resistance leads to higher current and power dissipation.
- Adjusting resistor values impacts the overall circuit behavior, enabling control over current flows and heat generation.

Additional Factors to Consider in Parallel Circuits

- **Total Resistance:** Always less than the smallest individual resistance in the parallel network.
- **Total Current:** Sum of individual branch currents, which can be higher than any individual current.
- **Power Dissipation:** Distributed among resistors based on their resistance and voltage.
- **Circuit Safety:** Proper resistor ratings and heat dissipation considerations are essential for circuit longevity and safety.

Practical Applications of Parallel Resistor Circuits

Parallel resistor networks are ubiquitous in electrical and electronic systems. Some common applications include:

- Voltage Regulation: Ensuring consistent voltage across components.
- Current Sharing: Distributing current to prevent overloads.
- Heat Management: Using resistor networks to dissipate heat effectively.
- Sensor Arrays: Parallel configurations in sensors to achieve desired electrical characteristics.
- Lighting Systems: Parallel wiring of bulbs to maintain consistent brightness.

Summary

Connecting a 27-ohm resistor and a 20-ohm resistor in parallel across a 240 V supply results in an equivalent resistance of approximately 11.49 Ω , with a total current of about 20.88 A flowing through the circuit. The individual currents are approximately 8.89 A through the 27 Ω resistor and 12 A through the 20 Ω resistor. The power dissipated in each resistor is roughly 2133 W and 2880 W, respectively, highlighting the importance of choosing resistors with adequate power ratings.

Understanding the principles of parallel resistor circuits enables engineers and technicians to design safe, efficient, and reliable electrical systems. Proper analysis ensures that components operate within their ratings, and circuit behavior aligns with theoretical predictions.

In conclusion, the scenario of a 27-ohm and a 20-ohm resistor connected in parallel across a 240-volt source exemplifies key concepts in circuit analysis. By methodically calculating the equivalent resistance, total current, individual currents, and power dissipation, one gains a comprehensive understanding of how parallel resistor networks function in real-world applications.

Frequently Asked Questions

What is the equivalent resistance of a 27 Ω and a 20 Ω resistor connected in parallel?

The equivalent resistance (R_{eq}) is given by $1/R_{eq} = 1/27 + 1/20$, which calculates to approximately 11.70 Ω .

What is the total current flowing through the parallel combination when connected across a 240V source?

Using Ohm's law, $I_{\text{total}} = V / R_{\text{eq}} = 240\text{V} / 11.70\Omega \approx 20.51\text{A}$.

How much power is dissipated across each resistor in the parallel circuit?

The power dissipated is $P = V^2 / R$. For the 27Ω resistor: $P = 240^2 / 27 \approx 2133.33\text{W}$; for the 20Ω resistor: $P = 240^2 / 20 = 2880\text{W}$.

Which resistor dissipates more power in this parallel circuit?

The 20Ω resistor dissipates more power (2880W) than the 27Ω resistor (2133.33W), since lower resistance results in higher power dissipation at the same voltage.

If the power rating of the resistors is 50W, are both resistors safe under these conditions?

No, both resistors dissipate over 2000W, which far exceeds typical 50W ratings; the resistors would overheat and potentially fail under these conditions.

Additional Resources

A 27- And A 20- Resistors Are Connected In Parallel, And The Combination Is Connected Across A 240-v

Introduction

In the realm of electrical engineering, understanding how resistors behave when connected in different configurations is fundamental to designing efficient circuits. One common setup involves connecting resistors in parallel, which significantly influences the overall resistance, current distribution, and power consumption of the circuit. Imagine a scenario where a 27-ohm resistor and a 20-ohm resistor are connected in parallel, and this combination is subsequently connected across a 240-volt power supply. Such arrangements are prevalent in various electronic and electrical applications, from household appliances to industrial machinery. This article delves into the principles underlying this configuration, exploring how to analyze the circuit, calculate key parameters, and interpret the results in a clear, comprehensive manner.

Understanding Parallel Resistor Connections

What Does Parallel Connection Mean?

A parallel resistor connection involves linking multiple resistors across the same two points of a circuit, forming multiple paths for current to flow. Unlike series connections, where resistors are connected end-to-end, parallel configurations allow electrons to choose among different paths, which impacts the total resistance and current flow.

Key Characteristics of Parallel Circuits

- **Shared Voltage:** All resistors connected in parallel experience the same voltage across their terminals.
- **Current Division:** The total current supplied by the source divides among the resistors inversely proportional to their resistances.
- **Reduced Total Resistance:** The equivalent resistance of parallel resistors is always less than the smallest individual resistor in the network.

Mathematically, the equivalent resistance (R_{eq}) of two resistors (R_1) and (R_2) in parallel is given by:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

This formula simplifies the analysis of complex circuits by replacing multiple resistors with a single equivalent resistor.

Calculating the Equivalent Resistance

Given the resistors:

- $(R_1 = 27\, \Omega)$
- $(R_2 = 20\, \Omega)$

The equivalent resistance (R_{eq}) can be calculated as:

$$\frac{1}{R_{eq}} = \frac{1}{27} + \frac{1}{20}$$

Calculating each term:

$$\frac{1}{27} \approx 0.03704$$
$$\frac{1}{20} = 0.05$$

Adding these:

$$\frac{1}{0.03704} + \frac{1}{0.05} = \frac{1}{0.08704}$$

Now, take the reciprocal to find R_{eq} :

$$R_{eq} = \frac{1}{0.08704} \approx 11.49 \, \Omega$$

This means that, from the perspective of the power supply, the combination of the 27-ohm and 20-ohm resistors behaves like a single resistor of approximately 11.49 ohms.

Powering the Circuit: Applying the 240V Supply

With the equivalent resistance known, analyzing the circuit's behavior becomes straightforward. Connecting this parallel resistor combination across a 240-volt source allows us to determine the total current supplied, the power dissipated, and the individual resistor currents.

Total Current Through the Circuit

Using Ohm's Law:

$$I_{total} = \frac{V}{R_{eq}}$$

Substituting the known values:

$$I_{total} = \frac{240 \, V}{11.49 \, \Omega} \approx 20.89 \, A$$

Thus, approximately 20.89 amperes of current flow from the power supply into the parallel network.

Power Dissipation in the Resistors

The total power consumed by the resistor network can be calculated via:

$$P_{total} = V \times I_{total}$$

which yields:

$$P_{total} = 240 \, V \times 20.89 \, A \approx 5013.6 \, W$$

\]

Alternatively, since power in a resistor can be calculated directly with:

\[

$$P = \frac{V^2}{R}$$

\]

for each resistor:

- 27-ohm resistor:

\[

$$P_{27} = \frac{(240)^2}{27} = \frac{57600}{27} \approx 2133.33 \text{ W}$$

\]

- 20-ohm resistor:

\[

$$P_{20} = \frac{(240)^2}{20} = \frac{57600}{20} = 2880 \text{ W}$$

\]

Adding these:

\[

$$2133.33 \text{ W} + 2880 \text{ W} = 5013.33 \text{ W}$$

\]

which closely matches the total power calculated earlier, confirming the internal consistency of the analysis.

Current Distribution in Each Resistor

Since the voltage across each resistor in a parallel circuit is the same (240 V), individual currents can be determined using Ohm's Law:

- Current through the 27-ohm resistor:

\[

$$I_{27} = \frac{V}{R} = \frac{240}{27} \approx 8.89 \text{ A}$$

\]

- Current through the 20-ohm resistor:

\[

$$I_{20} = \frac{240}{20} = 12 \text{ A}$$

\]

The sum of these currents:

$$\frac{1}{8.89 \text{ A} + 12 \text{ A}} = \frac{1}{20.89 \text{ A}}$$

confirms the earlier total current calculation, illustrating how current divides according to resistor values.

Practical Implications and Applications

Understanding the behavior of resistors in parallel is fundamental for designing circuits that require specific current flows and power dissipation characteristics. Some practical considerations include:

- Heat Dissipation: High power dissipation in resistors, as seen in this example, necessitates adequate heat sinking to prevent damage.
- Voltage Ratings: Resistors must be rated to withstand the voltage across them; in this case, 240 V is applied directly.
- Component Selection: Using resistors with appropriate power ratings (e.g., 5 W, 10 W, or higher) is vital to ensure longevity and safety.

In applications like heating elements, light dimmers, or power distribution networks, parallel resistor arrangements are common for controlling current and voltage levels effectively.

Safety Considerations in High-Voltage Circuits

When dealing with circuits powered by high voltages such as 240 V, safety becomes paramount:

- Insulation and Enclosures: Proper insulation prevents accidental contact with live parts.
- Circuit Breakers and Fuses: Protective devices safeguard against overloads and short circuits.
- Component Ratings: Ensuring all components, especially resistors, are rated for high voltage and power dissipation.
- Proper Grounding: Prevents electrical shocks and equipment damage.

Adhering to electrical safety standards and regulations is essential for both safety and compliance.

Conclusion

Connecting a 27-ohm resistor and a 20-ohm resistor in parallel across a 240-volt source provides a practical example of fundamental electrical principles in action. The combined resistance of approximately 11.49 ohms results in a total current of about 20.89 amperes and a total power dissipation nearing 5 kilowatts. This configuration illustrates how

parallel resistors influence current distribution, power consumption, and overall circuit behavior.

Understanding these principles not only aids in designing efficient electrical systems but also emphasizes the importance of safety and proper component selection when working with high-voltage circuits. Whether in industrial applications or everyday electronic devices, mastery of resistor networks and their analysis remains a cornerstone of electrical engineering.

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